

WHAT IS CLAIMED IS:

1        1. A method of implementing load balancing in a  
2        resilient packet ring ("RPR") network comprising a  
3        plurality of nodes and first and second rings each  
4        comprising a plurality of links for carrying information  
5        between the nodes in a clockwise direction and a  
6        counterclockwise direction, respectively, wherein  
7        adjacent ones of the nodes are connected by two of the  
8        links, the method comprising the steps of, for one of the  
9        nodes:

10            determining whether a load imbalance exists at the  
11          node in connection with a first class of service; and  
12            responsive to a determination that a load imbalance  
13          exists:

14            changing Bandwidth Broker ("BB") parameters at  
15          the node for the first class of service to cause new  
16          flows to be diverted from a more heavily loaded one of  
17          the rings to a less heavily loaded one of the rings; and

18            changing Quality of Service ("QoS") parameters  
19          at the node for the first class of service to improve  
20          traffic performance on the more heavily loaded one of the  
21          rings, while increasing bandwidth utilization on the less  
22          heavily loaded one of the rings.

1        2. The method of claim 1 wherein the step of  
2        determining is performed at periodic time intervals.

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1           3. The method of claim 1 wherein the step of  
2 determining is performed using a technique selected from  
3 the group consisting of measuring and comparing delays  
4 experienced by a test packet sent from the node to a  
5 second node via the first and second rings, respectively,  
6 and comparing a number of dropped packets on the first  
7 and second rings with a preselected maximum value.

1           4. The method of claim 1 further comprising the  
2 step of signaling to a QoS/BB monitor that a load  
3 imbalance has been detected responsive to a determination  
4 that a load imbalance exists.

1           5. The method of claim 1 wherein the step of  
2 changing the BB parameters comprises the steps of:  
3           decreasing an allocated bandwidth for the first  
4 class of service on the more heavily loaded ring; and  
5           increasing an allocated bandwidth for the first  
6 class of service on the less heavily loaded ring.

1       6. The method of claim 1 wherein the step of  
2 changing the QoS parameters comprises the steps of:

3            setting the peak traffic rate to the used bandwidth  
4 for the first class of service on the more heavily loaded  
5 ring;

6            reducing token bucket ("TB") parameters for all  
7 other classes of service on the more heavily loaded ring;

8            setting the peak traffic rate to the used bandwidth  
9 for the first class of service on the less heavily loaded  
10 ring; and

11           increasing the number of bytes in a class based  
12 queue ("CBQ") for the first class of service drained off  
13 in each scheduler rotation for each of the rings.

1       7. The method of claim 1 wherein the RPR network  
2 is a wavelength division multiplex RPR and the first and  
3 second rings are first and second wavelengths,  
4 respectively.

1        8. Apparatus for implementing load balancing in a  
2        resilient packet ring ("RPR") network comprising a  
3        plurality of nodes and first and second rings each  
4        comprising a plurality of links for carrying information  
5        between the nodes in a clockwise direction and a  
6        counterclockwise direction, respectively, wherein  
7        adjacent ones of the nodes are connected by two of the  
8        links, the apparatus comprising, at one of the nodes:

9            means for detecting at the node a load imbalance in  
10      connection with a first class of service;

11            means responsive to detection at the node of a load  
12      imbalance for changing Bandwidth Broker ("BB") parameters  
13      at the node for the first class of service to cause new  
14      flows to be diverted from a more heavily loaded one of  
15      the rings to a less heavily loaded one of the rings; and

16            means responsive to detection at the node of a load  
17      imbalance for changing Quality of Service ("QoS")  
18      parameters at the node for the first class of service to  
19      improve traffic performance on the more heavily loaded  
20      one of the rings, while increasing bandwidth utilization  
21      on the less heavily loaded one of the rings.

1        9. The apparatus of claim 8 wherein the means for  
2        detecting performs the detecting at periodic time  
3        intervals.

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1           10. The apparatus of claim 8 wherein the means for  
2 detecting comprises means for measuring and comparing  
3 delays experienced by a test packet sent from the node to  
4 a second node via the first and second rings.

1           11. The apparatus of claim 8 wherein the means for  
2 detecting comprises means for comparing a number of  
3 dropped packets on the first and second rings with a  
4 preselected maximum value.

1           12. The apparatus of claim 8 further comprising  
2 means for signaling to a QoS/BB monitor that a load  
3 imbalance has been detected.

1           13. The apparatus of claim 8 wherein the means for  
2 changing the BB parameters comprises:

3           means for decreasing an allocated bandwidth for the  
4 first class of service on the more heavily loaded ring;  
5 and

6           means for increasing an allocated bandwidth for the  
7 first class of service on the less heavily loaded ring.

1           14. The apparatus of claim 8 wherein the means for  
2        changing the QoS parameters comprises:

3           means for setting the peak traffic rate to the used  
4        bandwidth for the first class of service on the more  
5        heavily loaded ring;

6           means for reducing token bucket ("TB") parameters  
7        for all other classes of service on the more heavily  
8        loaded ring;

9           means for setting the peak traffic rate to the used  
10       bandwidth for the first class of service on the less  
11       heavily loaded ring; and

12          means for increasing the number of bytes in a class  
13        based queue ("CBQ") for the first class of service  
14        drained off in each scheduler rotation for each of the  
15        rings.

1           15. The apparatus of claim 8 wherein the RPR  
2        network is a wavelength division multiplex RPR and the  
3        first and second rings are first and second wavelengths,  
4        respectively.

1           16. Apparatus for implementing load balancing in a  
2        resilient packet ring ("RPR") network comprising a  
3        plurality of nodes and first and second rings each  
4        comprising a plurality of links for carrying information  
5        between the nodes in a clockwise direction and a  
6        counterclockwise direction, respectively, wherein  
7        adjacent ones of the nodes are connected by two of the  
8        links, the apparatus comprising, at one of the nodes:

9            a Quality of Service/Bandwidth Broker ("QoS/BB")  
10      monitor responsive to detection at the node of a load  
11      imbalance in connection with a first class of service for  
12      signaling to a BB to change BB parameters at the node for  
13      the first class of service to cause new flows to be  
14      diverted from a more heavily loaded one of the rings to  
15      a less heavily loaded one of the rings and for changing  
16      QoS parameters at the node for the first class of service  
17      to improve traffic performance on the more heavily loaded  
18      one of the rings, while increasing bandwidth utilization  
19      on the less heavily loaded one of the rings.

1           17. The apparatus of claim 16 wherein detection of  
2        a load imbalance is accomplished by measuring and  
3        comparing delays experienced by a test packet sent from  
4        the node to a second node via the first and second rings.

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1       18. The apparatus of claim 16 wherein detection of  
2 a load imbalance is accomplished by comparing a number of  
3 dropped packets on the first and second rings with a  
4 preselected maximum value.

1       19. The apparatus of claim 16 wherein the QoS/BB  
2 monitor is apprised of a load imbalance via an in-band  
3 signaling mechanism.

1       20. The apparatus of claim 16 wherein the QoS/BB  
2 monitor is apprised of a load imbalance via an out-of-  
3 band signaling mechanism.

1       21. The apparatus of claim 16 wherein the QoS/BB  
2 monitor changes the BB parameters by:

3       decreasing an allocated bandwidth for the first  
4 class of service on the more heavily loaded ring; and  
5       increasing an allocated bandwidth for the first  
6 class of service on the less heavily loaded ring.

1           22. The apparatus of claim 16 wherein the QoS/BB  
2 monitor changes the QoS parameters by:

3           setting the peak traffic rate to the used bandwidth  
4 for the first class of service on the more heavily loaded  
5 ring;

6           reducing token bucket ("TB") parameters for all  
7 other classes of service on the more heavily loaded ring;

8           setting the peak traffic rate to the used bandwidth  
9 for the first class of service on the less heavily loaded  
10 ring; and

11           increasing the number of bytes in a class based  
12 queue ("CBQ") for the first class of service drained off  
13 in each scheduler rotation for each of the rings.

1           23. The apparatus of claim 16 wherein the RPR  
2 network is a wavelength division multiplex RPR and the  
3 first and second rings are first and second wavelengths,  
4 respectively.